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# SATURATOR EFFICIENCY AND UNCERTAINTY OF NIS PRIMARY STANDARD FOR RELATIVE HUMIDITY CALIBRATION

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***ABSTRACT***

***In the last ten years, there has been associate interest of makers and laboratories in having more accurate humidity measurements. Electrical relative humidity (RH) sensors have been widely used. These sensors need to be calibrated, and therefore the uncertainty measurement of these sensors has become a major concern. This paper describes the relative humidity uncertainty analysis and uncertainty contribution from saturator efficiency for the National Institute of Standards' (NIS-Egypt) two-pressure humidity generator. Efficiency tests were administrated. The saturator efficiency test results showed smart performance of the generator, as described below. Uncertainty analysis was also represented for all the sources that touch measurements. The expanded uncertainty of a coverage factor k=2 was found to be from ± 0.1% to ± 0.45% for relative humidity.***

***KEYWORDS: Efficiency, Saturator, Uncertainty & Generator***

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Original Article

## 1. INTRODUCTION

The responsibilities of the Temperature measurement laboratory in NIS include humidity measurement, up-keep and improvement of standards. Humidity measurements became more and more necessary, particularly within the industrialised world science. It has been recognized that humidity has a significant effect on the quality of life, quality of merchandise, safety, cost, and health. This event has caused a major increase in humidity measurement applications and whereas, a rise in analysis and development activities to improve measurement techniques, accuracy, dependableness and reliability of instrumentations [3].

Air humidity will be expressed as dew point temperature, absolute humidity, and relative humidity. Relative humidity (RH) is the common term used to specify the quantity of vapour contained in moist air. There are many techniques on the market, to get humidity references by employing a stream of saturated gas with well-known water-vapour content as Saturated Salt Solution fixed-point systems, two-pressure humidity generators, two-temperature humidity generators, and two-flow humidity generators [4]. In this paper, operation of the humidity generator rests on the two-pressure method of producing known atmospheres of relative humidity, and assumes that the water vapour pressure remains a fraction of the overall pressure, referred to as Dalton's Law of Partial Pressure. Dalton's Law states that the pressure exerted by a mix of gases in an exceedingly given volume at some temperature matches add of the pressures, which might be exerted by every gas if it alone occupied the amount at similar temperature. RH in a two-pressure humidity generator is set from the measurements of temperature and pressure only.

Eq. (1) shows relative humidity calculation employing a two-pressure humidity generator [1]

$$RH = \frac{Pc}{Ps} * \frac{Es}{Ec} * \frac{Fs}{Fc} * 100 \quad (1)$$

Where,

**Pc:** Pressure of the Chamber

**Ps:** Pressure at Saturation

**Es, Ec:** Saturation Vapour Pressure at Saturation and Chamber Temperature

**Fs, Fc:** Enhancement Factor at Saturation and Chamber Temperature and Pressure

Saturator efficiency is the degree of the saturated air, defined as the ratio of actual vapour pressure at the saturator exit to the ideal vapour pressure [5] that is additionally examined by employing a transfer standard chilled mirror dew point meter factory-made by MBW, model DP-30.

## 2. SOURCES OF UNCERTAINTY

### 2.1 Uncertainty Contribution from the Pressure Ratio $P_c$ /$P_s$

The pressure ratio, chamber pressure/saturation pressure, in a two-pressure humidity generator is the affective % RH determining factor, since each the Es/Ec and Fs/Fc ratios are nearly equal to 1. Under these conditions, relative humidity= chamber pressure /saturation pressure *100. Eq. (2) shows Relative humidity uncertainty due to pressure [6].

$u(P) = \pm\{[(P_c \pm uP_c)/(Ps \pm uP_s) * F_s/F_c * E_s/E_c * 100] -$ relative humidity . (2)

The equation may be simplified by subbing $F_s/F_c = 1$ and $E_s/E_c = 1$ as shown in Eq.(3)

$u(P) = \pm\{(P_c \pm uP_c)/(P_s \pm uP_s) - (P_c/P_s)\} * 100$ (3)

Where, u(P) is uncertainty in relative humidity due to pressure

$uP_c$, $uP_s$: chamber and saturation pressure measurement uncertainty

There are many sources in determining components of uncertainty, like measurement uncertainty, measurement hysteresis and resolution.

#### 2.1.1 Pressure Uncertainty Components

Each transducer was calibrated at four points over the range, resulting at least 30 measurements

The standard deviation from the desired mean values is: Std dev upc= 0.0333 psia for P < 50 psia, Std dev $up_c$= 0.0058psia for P>50 psia.

**For saturation pressures below 50 psia,** Eq. (4,5) shows uncertainty in pressure measurement

$u(Pc) = \pm\{(Pc + uPc)/(Ps + uPc) - (Pc/Ps)\} * 100$ (4)

= ± {(14.7 + 0.0333)/(15 + 0.0333) – (14.7/15)} * 100=±0.0003 % (saturation pressure =15, relative humidity = 98%)

= ± {(14.7+0.0333)/(20 + 0.0333) – (14.7/20)} * 100=±0.044 % (saturation pressure =20, relative humidity = 73.50%)

= ±{(14.7 + 0.0333)/(35 + 0.0333) – (14.7/35)} * 100=±0.055 % (saturation pressure =35, relative humidity = 42%)

= ±{(14.7 + 0.0333)/(50 + 0.0333) – (14.7/50)} * 100=±0.046 % (saturation pressure =50, relative humidity = 29.4%)

$$u(Ps) = \pm\{(Pc)/(Ps \pm uPs) - (Pc/Ps)\} * 100 \quad (5)$$

= ± {(14.7)/(14.5 ± 0.0333 ) - (14.7/14.5 )} * 100 =0.022% (saturation pressure =15, relative humidity =98%)

= ±0.012 % (saturation pressure =20, relative humidity =73.50%)

= ±0.0039 % (saturation pressure =35, relative humidity =42.00%)

= ±0.002 % (saturation pressure =50, relative humidity =29.40%)

**For saturation pressures above 50 psia,** Eq. (6, 7) shows Relative humidity uncertainty contributions due to the pressure ratio term

$$u(P_c) = \pm\{(P_c \pm uP_c)/(P_s) - (P_c/P_s)\} * 100 = \pm\{\pm uP_c/P_s\} * 100 \quad (6)$$

= ± {0.0058/50} * 100 = ±0.012 %RH (saturation pressure =50, pc=14.7, %RH= Pc/Ps*100 = 29.40%)

= ± { 0.0058/85} * 100 = ±0.0068 % (saturation pressure =85, relative humidity =17.30%)

= ± {0.0058/100} * 100 = ±0.0058 % (saturation pressure =100, relative humidity =14.70%)

= ± {0.0058/150} * 100 = ±0.0034% (saturation pressure =150, relative humidity =9.8%)

$$u(P_s) = \pm\{(P_c)/(P_s \pm uP_s) - (P_c/P_s)\} * 100 \quad (7)$$

= ±{(14.7)/(50 ± 0.0058) – (14.7/50)} * 100 = ±0.0034 % (saturation pressure =50, relative humidity =29.40%)

= ± {(14.7)/(85 ± 0.0058) – (14.7/85)} * 100 = ±0.0012 % (saturation pressure =85, relative humidity =17.3%)

= ± {(14.7)/(100 ± 0.0058) – (14.7/100)} * 100 = ±0.00085 % (saturation pressure =100, relative humidity =14.70%)

= ±{(14.7)/(150 ± 0.0058) – (14.7/150)} * 100 = ±0.0038 % (saturation pressure =150, relative humidity =9.80%)

Where, $u(P_c)$ chamber pressure $P_c$ relative humidity uncertainty $u(P_s)$ saturation pressure and $P_s$ relative humidity uncertainty

### 2.1.2 Uncertainty in Pressure Resolution

The uncertainty component of pressure resolution is shown in Eq. (8)

$$\text{Resolution} = (\text{Transducer Range})/25000*0.5/\sqrt{3} \quad (8)$$

Chamber pressure measurement resolution uncertainty, $u(RP_c)$, and saturation pressure measurement resolution, u(RPs) shown in Eq. (9,10)

$$u(RP_c) = \pm\{\text{resolution/ saturation pressure}\} * 100 \quad (9)$$

$$u(RP_s) = \pm\{(\text{chamber pressure})/(\text{saturation pressure} \pm \text{resolution}) - (\text{chamber pressure} / \text{saturation pressure})\}*100 \quad (10)$$

At chamber pressure of 14.7 psia and the saturation pressure range of 15 to 150 psia, the uncertainties due to resolution is

Chamber pressure measurement resolution uncertainty= ±0.0039% (saturation pressure =15, relative humidity =98)

= ±0 .0029% (saturation pressure =20, relative humidity =73.50%)

= ± 0.00165% (saturation pressure =35, relative humidity =42.00%)

= ± 0.0012% (saturation pressure =50, relative humidity =29.40%)

= ± 0.00068% (saturation pressure =85, relative humidity =17.30%)

= ±0.001 % (saturation pressure =100, relative humidity =14.70%)

= ±0.000 % (saturation pressure =150, relative humidity =9.80%)

Saturation pressure measurement resolution = ±0.011 % (saturation pressure =15, relative humidity =98%)

= ±0.002 % (saturation pressure =20, relative humidity =73.50%)

= ± 0.00069% (saturation pressure =35, relative humidity =42.0%)

= ±0.0012 % (saturation pressure =50, relative humidity =29.40%)

= ±0.00035 % (saturation pressure =85, relative humidity =17.30)

= ±0.00025 %( saturation pressure =100, relative humidity =14.70%)

= ±0.00011 % (saturation pressure =150, relative humidity =9.80%)

**2.1.3 Uncertainty Due to Pressure Hysteresis**

Eq. (11) shows The uncertainty, u(H),

$$u(H) = \pm\{(\text{chamber pressure} + \text{Hysteresis})/(\text{saturation pressure}) - (\text{chamber pressure} / \text{saturation pressure})\}*100 \quad (11)$$

The hysteresis is estimated as +0.1% of the measured difference between the saturation and chamber pressures shown in Eq. (12)

$$\text{Hysteresis} = (0.1\% * (\text{saturation pressure} - \text{chamber pressure}))/\sqrt{3} = 0.00058 * (\text{saturation pressure} - \text{chamber pressure}) \quad (12)$$

According to Eq. (11), the uncertainty component is shown as,

u (H) = ±{( chamber pressure + 0.00058*( saturation pressure - chamber pressure))/(saturation pressure) – (chamber pressure / saturation pressure)} * 100 = ±0.058(1- chamber pressure / saturation pressure) = ±0.00058(100- relative humidity)

Uncertainty due to hysteresis at various saturation pressures between saturation pressure =15 and 150 psia (with chamber pressure =14.7) is

Hysteresis uncertainty = ±0.0012 % (saturation pressure =15, relative humidity=98%)

= ±0.015 % (saturation pressure =20, relative humidity =73.50%)

= ±0.034 % (saturation pressure =35, relative humidity =42.00%)

= ±0.041 % (saturation pressure =50, relative humidity =29.40%)

= ±0.048 % (saturation pressure =85, relative humidity =17.3%)

= ±0.049 % (saturation pressure =100, relative humidity =14.7%)

= ±0.052 % (saturation pressure =150, relative humidity =9.80%)

Eq. (13) shows the standard uncertainty, uc (chamber pressure / saturation pressure), in the pressure ratio chamber pressure / saturation pressure that is determined from the associated individual components previously shown.

$$uc^2 \text{ (chamber pressure / saturation pressure)} = u^2 \text{ (chamber pressure)} + u^2 \text{ (saturation pressure)} + u^2 (Rpc) + u^2 (Rps) + u^2 (H) \quad (13)$$

Table 1 shows the relative humidity standard uncertainty because of pressure at various pressures from 15 psia to 150psia. The combined uncertainty ranged from 0.02% to 0.06%.

**Table 1: Standard Uncertainty Components of RH due to Pressure**

| **Standard Uncertainty Components of RH due to Pressure** | | | **Low-Pressure Range, $P_s$ <50** | | | | **High-Pressure Range, $P_s$ >50** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Symbol** | **Symbol** | **Type** | **15** | **20** | **35** | **50** | **50** | **85** | **100** | **150** |
| Measurement | U(pc) | A | 0.0003 | 0.044 | 0.055 | 0.046 | 0.012 | 0.0068 | 0.0058 | 0.0058 |
| Measurement | U(pc) | A | 0.022 | 0.012 | 0.0039 | 0.002 | 0.0034 | 0.0012 | 0.00085 | 0.0038 |
| Pc Resolution | u(RPc) | B | .0039 | 0.0029 | 0.00165 | 0.0012 | 0.0012 | 0.00068 | 0.01 | 0.00 |
| Ps Resolution | u(RPs) | B | 0.011 | 0.002 | 0.00069 | 0.0012 | 0.0012 | 0.00035 | 0.00025 | 0.0001 |
| Hysteresis | u(H) | B | 0.0012 | 0.015 | 0.034 | 0.041 | 0.041 | .048 | 0.049 | 0.052 |
| Combined uncertainty | | | **0.02494** | **0.0481** | **0.0648** | **0.06168** | **0.04289** | **0.0485** | **0.05035** | **0.0525** |

### 2.2 Uncertainty Contribution from the Vapour Pressure Ratio Term $E_s$ /$E_c$

Vapour Pressure Ratio Uncertainty, Es /Ec, Es and Ec are Saturation Vapour Pressures, computed at the saturation temperature and chamber temperature, respectively. In an ideal two-pressure humidity generator, the saturation temperature and chamber temperature would be equal, resulting in an ideal Es /Ec ratio of 1. In a system, differences exist between the saturation and chamber temperatures. With the known assumptions that Fs/Fc =1, and Pc/Ps *100 =RH. Eq. (14) shows the participation due to temperature is

$$u(T) = \pm\{\text{ chamber pressure / Saturation pressure } *(E[T_s \pm uT_s])/(E[T_c \pm uT_c]) * F_s/F_c\}*100 - RH$$

$$= \{(E[T_s \pm uT_s])/(E[T_c \pm uT_c]) -1\} * RH \quad (14)$$

Where, u(T) is uncertainty in RH due to temperature

$uT_c$: uncertainty of chamber temperature

$uT_s$ : uncertainty of saturation temperature

$E[T_s - uT_s]$ = Saturation Vapor Pressure computed at the Saturation Temperature, Ts, when perturbed by the possible temperature uncertainty, $uT_s$

### 2.2.1 Uncertainty n Temperature Resolution

The uncertainty component of temperature resolution is shown in Eq. (15)

$$\text{Resolution} = 0.01 * 0.5/\sqrt{3} = 0.0029 \quad (15)$$

The uncertainty due to chamber temperature resolution, u(RTc), and saturation temperature resolution u(RTs), are given as shown in Equations (16,17)

$$u(\text{chamber temperature resolution}) = \pm \{(E_{Ts}/E_{Tc+0.0029}) - 1\} * \text{relative humidity} \quad (16)$$

$$u(\text{saturation temperature resolution}) = \pm \{(E_{Ts+0.0029}/E_{Tc}) - 1\} * \text{relative humidity} \quad (17)$$

Chamber temperature resolution uncertainty = ± 0.00024 * RH (saturation temperature = chamber temperature =0°C)

= ± 0.0002 * relative humidity (saturation temperature = chamber temperature =35°C)

= ± 0.0013 * relative humidity (saturation temperature = chamber temperature =70°C)

Saturation temperature resolution uncertainty = ± 0.00024 * RH (saturation temperature = chamber temperature =0°C)

= ± 0.0002 * relative humidity (saturation temperature = chamber temperature =35°C)

= ± 0.0013 * relative humidity (saturation temperature = chamber temperature =70°C)

### 2.2.2 Uncertainty Due to Self-Heating of Chamber Temperature

The self-heating, with temperature measurements, is estimated to be 0.017

So, Self-Heating = $0.017 * T_c /\sqrt{3} = 0.0098 * T_c$

Relative humidity uncertainty due to self-heating of the chamber temperature probe is as shown in Eq. (18)

$$u(SH) = \pm \{(E_{Ts}/E_{0.0098*Tc}) - 1\} * RH \quad (18)$$

Self-heating uncertainty= ± 0 (saturation temperature = chamber temperature =0°C)

u(SH) = ± 0.0006 * relative humidity (saturation temperature = chamber temperature =35°C)

u(SH) = ± 0.00095 * relative humidity (saturation temperature = chamber temperature =70°C)

The standard uncertainty of RH due to temperature, $uc(E_s/E_c)$, in the saturation vapor pressure ratio $E_s/E_c$ is determined using equation (19)

$$u_c^{\,2}(E_s/E_c) = u^2(R_{Tc}) + u^2(R_{Ts}) + u^2(SH) \quad (19)$$

Table 2 shows the standard uncertainty of RH due to temperature, $uc(E_s/E_c)$

**Table 2: Standard Uncertainty Components of RH Due to Temperature**

| Relative Humidity Standard Uncertainty Components | | | Temperature | | |
|---|---|---|---|---|---|
| **Source** | **Symbol** | **Type** | **0 °C** | **35 °C** | **70 °C** |
| Tc resolution | u(Tc) | B | 0.00024 | 0.0002 | 0.0013 |
| Ts resolution | u(Ts) | B | 0.00024 | 0.0002 | 0.0013 |
| Self-heating | U(SH) | B | 0 | 0.0006 | 0.00095 |
| Combined uncertainty | | | 0.000339 | 0.000663 | 0.002069 |

### 2.3 Uncertainty Contribution from Saturator Efficiency

The humidity generation in a two-pressure humidity generator depends on that, the generator has a pre-saturator to saturate the air with water vapour before entering the main saturator. The pre-saturator has been equipped with an RTD and temperature controller, to maintain its temperature 15 $^{o}$C to 20 $^{o}$C higher than the main saturation temperature. The measuring of saturator efficiency was done by changing the pre-saturation temperature from 35 $^{o}$C to 40 $^{o}$C for chamber temperature setting at 20 $^{o}$C, and from 40 $^{o}$C to 45 $^{o}$C for chamber temperature setting at 25 $^{o}$C with an increment of 1 $^{o}$C at Three relative humidity set points, 10, 50, and 90 % RH for covering the range. The gas flow rate was set at 20 L/ h, and then much the temperature of the dew-point temperature.

The saturator efficiency was done by measuring the dew point at an outlet saturator, using a transfer standard MBW chilled mirror dew point meter DP30. When the measured dew point doesn't depend on the pre-saturator temperature anymore and will be than constant [7,8], complete saturation has been achieved. The dew point uncertainty by saturator efficiency was measured from the differences between generated dew points and measured dew points, where the biggest deviation was chosen.

Equation (20) used to convert this dew point uncertainty in term of relative humidity,

$$U(RH,sat\text{-}eff)=\pm\frac{(RH\text{-}e(td+бtd)*100}{e(t)} \tag{20}$$

Where, бtd is the dew point deviation, t is the chamber temperature.

To get standard uncertainty of dew point from saturator efficiency, the dew points generated by the generator subtracted by the measured dew points called dew point deviations. The results showed that the saturator efficiency gives the largest impact to relative humidity uncertainty 0.25 % RH at very high humidity (95 %RH) and gives a smaller impact, as the humidity decreases to 0.15% RH.

The efficiency of the saturation process is estimated at 100 ± 0.25% with the triangular distribution. The standard uncertainty component, because of saturator efficiency, once determined at the relative humidity being generated, is therefore computed as saturator efficiency uncertainty = 0.25/√6 * relative humidity = 0.102 * relative humidity

## 3. COMBINED STANDARD UNCERTAINTY

The combined standard uncertainty ($u_c$(RH) ) is calculated from a statistical combination of the standard uncertainty of all components, as shown in Eq (21)

$$uc^{2}(RH) = uc^{2}(Pc/Ps) + uc^{2}(Es/Ec) + + uc^{2}(S\text{-}eff) \tag{21}$$

## 4. EXPANDED UNCERTAINTY

The expanded uncertainty, U, with coverage factor k=2, is shown in the following tables. The table 3 shows the expanded uncertainty at various temperatures (0,35, 70$^o$C) and relative humidity (from 10% tom 98%).

**Table 3: Expanded Uncertainty at Various Temperatures and Humidity**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **At 0°C** | | | | | | | | | | |
| **Source** | **Symbol** | **Type** | **Low-Pressure Range, $P_s$ <50** | | | | **High-Pressure Range, $P_s$ >50** | | | |
| | | | **15** | **20** | **35** | **50** | **50** | **85** | **100** | **150** |
| | | | **98% RH** | **73.5% RH** | **42% RH** | **29.4% RH** | **29.4% RH** | **17.3% RH** | **14.7% RH** | **9.8% RH** |
| Pressure Ratio | $u(P_c/P_s)$ | A,B | 0.0249 | 0.04814 | 0.0648 | 0.0617 | 0.042889 | 0.0485 | 0.05035 | 0.0525 |
| Vapour Pressure Ratio | $u(E_s/E_c)$ | B | 0.0332 | 0.02492 | 0.0142 | 0.0099 | 0.00997 | 0.005865 | 0.00498 | 0.00332 |
| Saturator Efficiency | U(S-eff) | B | 0.0999 | 0.07497 | 0.0428 | 0.0299 | 0.02999 | 0.01765 | 0.01499 | 0.00999 |
| **Combined uncertainty** | | | 0.1082 | 0.09251 | 0.0789 | 0.0693 | 0.05327 | 0.05194 | 0.05277 | 0.05351 |
| **Expanded uncertainty (k=2)** | | | **0.2164** | **0.18503** | **0.1579** | **0.139** | **0.10655** | **0.10389** | **0.10555** | **0.10702** |
| **At 35°C** | | | | | | | | | | |
| **Source** | **Symbol** | **Type** | **Low-Pressure Range, $P_s$ <50** | | | | **High-Pressure Range, $P_s$ >50** | | | |
| | | | **15** | **20** | **35** | **50** | **50** | **85** | **100** | **150** |
| | | | **98% RH** | **73.5% RH** | **42% RH** | **29.4% RH** | **29.4% RH** | **17.3% RH** | **14.7% RH** | **9.8% RH** |
| Pressure Ratio | $u(P_c/P_s)$ | A,B | 0.0249 | 0.048139 | 0.0648 | 0.0616 | 0.042889 | 0.0485 | 0.05035 | 0.05246 |
| Vapor Pressure Ratio | $u(E_s/E_c)$ | B | 0.0649 | 0.048731 | 0.0278 | 0.0194 | 0.019492 | 0.011469 | 0.009746 | 0.006497 |
| Saturator Efficiency | U(Seff) | B | 0.0999 | 0.07497 | 0.0428 | 0.0299 | 0.029988 | 0.017646 | 0.014994 | 0.009996 |
| **Combined uncertainty** | | | 0.1218 | 0.101551 | 0.0825 | 0.0712 | 0.055845 | 0.05287 | 0.053434 | 0.053798 |
| **Expanded uncertainty(k=2)** | | | **0.2436** | **0.203102** | **0.1650** | **0.1425** | **0.11169** | **0.105739** | **0.106869** | **0.107596** |
| **At 70°C** | | | | | | | | | | |
| **Source** | **Symbol** | **Type** | **Low-Pressure Range, $P_s$ <50** | | | | **High-Pressure Range, $P_s$ >50** | | | |
| | | | **15** | **20** | **35** | **50** | **50** | **85** | **100** | **150** |
| | | | **98% RH** | **73.5% RH** | **42% RH** | **29.4% RH** | **29.4% RH** | **17.3% RH** | **14.7% RH** | **9.8% RH** |
| Pressure Ratio | $u(P_c/P_s)$ | A,B | 0.0249 | 0.048139 | 0.0648 | 0.0616 | 0.042889 | 0.0485 | 0.050353 | 0.05246 |
| Vapor Pressure Ratio | $u(E_s/E_c)$ | B | 0.2027 | 0.152072 | 0.0868 | 0.0608 | 0.060829 | 0.03579 | 0.030414 | 0.020276 |
| Saturator Efficiency | U(Seff) | B | 0.0999 | 0.07497 | 0.0428 | 0.0299 | 0.029988 | 0.017646 | 0.014994 | 0.009996 |
| **Combined uncertainty** | | | 0.2274 | 0.176249 | 0.1165 | 0.0916 | 0.080242 | 0.062808 | 0.060706 | 0.057124 |
| **Expanded uncertainty(k=2)** | | | **0.4548** | **0.352498** | **0.2331** | **0.1833** | **0.160485** | **0.125616** | **0.121413** | **0.114248** |

## 5. CONCLUSIONS

To improve the calibration processes of relative humidity, our primary standard two-pressure humidity generator was characterised and tested. Analysis of saturator efficiency has been done by changing the pre-saturator temperature in 1$^o$C steps, whereas validity was done by comparison our relative humidity calculation with Thunder Scientific Corporation. The experimental results were shown that the fluctuation of dew point caused by saturator efficiency contributes ±0.15 % and ±0.25 %. The relative humidity uncertainty due to pressure, temperature and saturator efficiency of two-pressure humidity generator ranged from± 0.1% to ±0.45 %.

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